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Laser versus non-laser stapedotomy in otosclerosis: A systematic review and meta-analysis

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ABSTRACT

Objective: To compare and evaluate the hearing outcome and complications of otosclerosis treated with the laser or non-laser stapedotomy using meta-analysis.
Methods: A thorough search for publications and "in-process" articles with English abstract dating from January 1978 to July 2013 was conducted using Pubmed, EBSCO and Web of Science databases, as well as all related papers. The included criteria were otosclerosis as diagnosis, clear description of surgical methods, calibrated stapedotomy and regular collection of functional results. Hearing results and other comparable data (age, preoperative hearing status, and mean length of follow-up) were collected from the articles.
Results: Eleven studies with a total of 1614 subjects were identified to meet our criteria. There was a significant difference in the efficacy of stapedotomy with the laser or non-laser technique; current data showed a combined RR of 1.07 (95% CI: 1.02–1.13, $p = 0.005$). But, the postoperative complication showed no advantage for the laser group, with a combined RR of 0.63 (95% CI: 0.30–1.34, $p = 0.23$). Although there was publication bias in this study ($p = 0.005$), the funnel plot would turn out to be symmetrical after six more studies were added by the trim and fill method.
Conclusion: Our overall results suggest that the laser stapedotomy had significantly better hearing results than non-laser stapedotomy. However, current papers on laser and non-laser stapedotomy did not provide enough subjects to make a subgroup analysis of the hearing outcome between different laser groups. More studies reporting different laser techniques are required to provide us with a better understanding of laser stapedotomy.

1. Introduction

Patients with otosclerosis present with progressive hearing loss due to the fixation of the stapes. Stapes surgery is put forward to resolve the progressive conductive or mixed hearing loss. Since the early 1970s, the small-fenestra stapedotomy technique has become a standard surgery for its fewer trauma and better hearing results [1]. Fenestration on a fixed footplate may be performed by the help of a perforator, microdrill, pick, piezoelectric device, or a laser. The ideal technique should permit providing a full round hole without direct damage to the vestibule of the inner ear. The conventional techniques, primarily perforators and microdrills, are still widely used due to ease of use. The footplate, especially when it is only a shell of the bone, can be easily perforated with the manual perforators or microdrill without the risk of inner ear damage or footplate mobilization. The superiority of any one of these methods that use the perforator, microdrill, pick and piezoelectric device, was not determined with regard to the ABG closure due to their mechanical effect [2–4]. Therefore, these traditional techniques can be summarized as the non-laser group to be compared with laser stapedotomy.

Recently, the use of laser technique is increasing gradually with developing technology. The argon laser was the first laser system to be clinically used for stapedotomy and was reported to have good results by Palva [5] in 1978. From then on, all different types of laser systems, such as KTP, argon, erbium, YAG and CO_2 lasers, were assessed for their suitability for stapes footplate perforation [6–11]. But none of them were believed to have any overwhelming advantage over the others in audiological results post-operatively [12–14], although the main advantages of the laser included the high precision of its application, the high ablation efficiency, and the low risk of floating footplate due to the noncontact

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manipulation of these systems [6]. Several studies showed the negative impact of the laser used in otologic surgery, causing heat or pressure trauma, consequently impairing hearing [6,15–17]. When it was compared with non-laser stapedotomy, current studies also have generated conflicting results. Arnoldner et al. [6] found that ABG closure was significantly changed in more frequencies in the conventional group than in the Er:YAG laser group and threshold shifts of bone conduction in the laser group were not only more significant, but also not totally reversible. McGee [18] compared the audiological results of patients operated by argon laser and conventional techniques, finding no significant statistical difference in the audiologic results. However, Garin et al. [19] concluded that the laser-assisted procedure performed better than the non-laser procedure, and Motta and Moscillo [7] reported that the CO_2 laser technique provided hearing outcomes superior to those of non-laser operation after stapes surgery. Therefore, the aim of this study was aimed to confirm by meta-analysis whether the laser stapedotomy was superior to the non-laser stapedotomy in terms of the surgical effectiveness and safety.

2. Materials and methods

2.1. Search strategy

Pubmed, EBSCO and Web of Science databases were searched to obtain comparative research between laser and non-laser stapedotomy published from January 1978 to July 2013, by using the keywords defined as stapes surgery, otosclerosis and stapedotomy in the literature. Relevant researches were also reviewed from the reference lists of enrolled papers in a manual way. The inclusion of papers for the current meta-investigation were restricted to those with text and/or abstracts in English.

2.2. Study selection criteria

We included articles for this study according to the following criteria: (1) research designed prospectively or retrospectively to compare the postoperative function of laser stapedotomy and non-laser stapedotomy in otosclerosis; (2) randomized controlled trial (RCT) research designed to compare the hearing status after laser stapedotomy and conventional stapedotomy during the same period.

Studies not reporting postoperative hearing condition were excluded from the current investigation. Duplicated studies were also excluded by examining the patient institutions, sample sizes, author lists, and research time. When the population groups were specially selected patient groups, such as "recurrent otosclerosis" or "otosclerosis in children," the study was not included in order to control heterogeneity of this study as soon as possible.

2.3. Data extraction

Data were independently collected by two co-authors (LF and HL) from each included trials; any difference was subsequently settled by discussion. The quantitative data were as follows: the number of patients with postoperative ABG $\leq$10 dB, mean postoperative ABG, mean length of follow-up, and the number of complications. Fig. 1 gives a flow chart showing the extraction process of the paper.

2.4. Outcome measure

A postoperative ABG closure of $\leq$10 dB was used to assess the efficacy of different stapedotomies, and the complications as clinical indications for cochlear and vestibular function. The number of patients with postoperative ABG closure $\leq$ 10 dB was

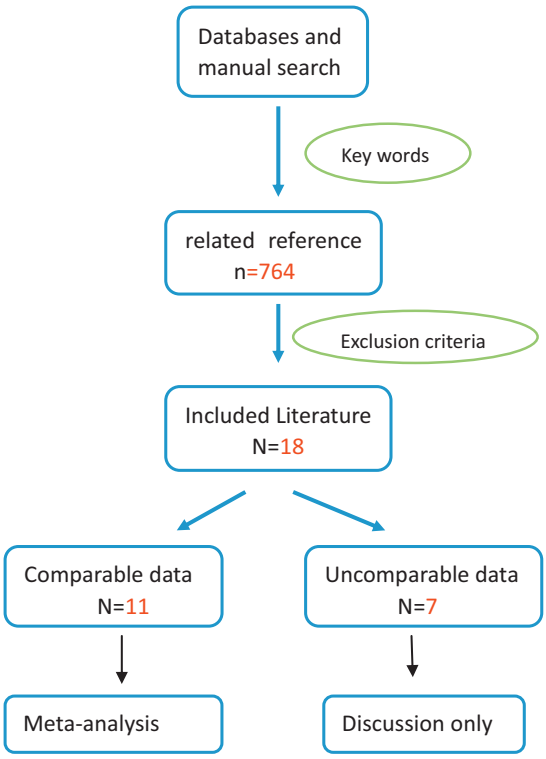

Fig. 1. Flow diagram showing the methodology of the study.

either reported by the authors or calculated from their data and could be compared among all studies. The complication including sensorineural hearing loss and tinnitus and vertigo was published in only seven studies. To assess the efficacy and safety of stapedotomy, the mean length of the follow-up period and the average value of preoperative ABG, usually calculated at 0.5, 1, 2, and 3 kHz, were also applied together for analysis. However, if the study provided only the mean value based on different individual frequencies, we accepted it whenever it was possible. Table 1 shows the characteristics of all the references, including the type of study, the average value of preoperative ABG, the number of patients with postoperative ABG $\leq$10 dB and the mean length of the follow-up.

2.5. Statistical analysis

For meta-analysis of the measure of association, risk ratio (RR) and its 95% confidence interval (CI) were calculated (Stata 11; Stata Corporation, Lakeway Drive, College Station, TX, USA). For analysis, a result of the 95% CI not including 1 was assumed statistically significant. We evaluated evidence of heterogeneity with I^2 and p values. In case of $p > 0.10$ and/or $I^2 \leq 50\%$, we did not take heterogeneity into consideration and applied a fixed-effects model (Mantel–Haenszel's method) for analysis. For other cases, a random-effects model (DerSimonian and Laird's method) was employed. A meta-regression was used to examine whether the preoperative ABG, and mean follow-up time value would influence the efficacy of stapedotomy. In addition, Egger's test and funnel plot were used to measure the possible publication bias. We conducted further sensitivity analyses by using trim and fill method (Duvall and Tweedie's method) to test and adjust for publication bias [20]. For asymmetric funnel plot, estimated values for missing studies were made up and the studies resulting in the asymmetry were trimmed. If a small study was a source of asymmetry, the filled studies should be located at the bottom of the triangle.